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Report to the Chairman, Committee on Governmental Affairs, U.S. Senate

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TECHNOLOGY DEVELOPMENT

Future Use of NASA's Large Format Camera Is Uncertain

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The Honorable John Glenn
Chairman, Committee on
Governmental Affairs
United States Senate

Dear Mr. Chairman:

As you requested, we reviewed the National Aeronautics and Space Administration's (NASA) use of its Large Format Camera. Specifically, we reviewed the reasons the camera has been in storage since its first and only flight in 1984 and the possible uses of the camera in the future.

We are sending copies of this report to the Administrator of NASA, appropriate congressional committees, and other interested parties. We will make copies available to others upon request.

Please contact me at (202) 275-5140 if you or your staff have any questions concerning the report. Appendix III lists the major contributors to this report.

Sincerely yours,

Mark E. Gebicke

Mark E. Gebicke
Director, NASA Issues

Executive Summary

Purpose

In the mid-1970s, the National Aeronautics and Space Administration (NASA) developed plans to demonstrate its ability to take high-resolution three-dimensional photographs from space with a precision camera known as the Large Format Camera. The cost to develop and procure this camera was $11.4 million. It was flown only once, in 1984, on the shuttle Challenger. Since this flight, it has been in storage, first at the Johnson Space Center and now at the Stennis Space Center.

The Chairman of the Senate Committee on Governmental Affairs asked GAO to determine (1) why the camera has been in storage since its first and only flight in 1984 and (2) whether it could be used in the future.

Background

NASA developed the Large Format Camera as a "technology demonstration project," which it defines as a project to verify an engineering concept or design. The primary purpose of the Large Format Camera, which was a major component of the Orbiter Camera Payload System, was to enhance worldwide topographic mapping precision with high-resolution space photography.

Results in Brief

In using the Large Format Camera aboard the shuttle in 1984, NASA successfully demonstrated the camera's capabilities. However, NASA never intended to use the camera on every shuttle mission. Rather, NASA expected that, following the camera's successful demonstration, other government agencies or private companies with special interests in photographic applications would absorb the costs for further flights using the Large Format Camera. But, because shuttle transportation costs for the Large Format Camera were estimated to be approximately $20 million (in 1987 dollars) per flight and the market for selling Large Format Camera products was limited, NASA was not successful in interesting other agencies or private companies in paying the costs to use it on the shuttle.

In addition, NASA officials said that using the camera on its space station does not appear to be a realistic alternative. They cite several reasons for this, including (1) the uncertainty of when the station will be operational and (2) the station's design restrictions and flight pattern, which will limit the camera's picture-taking opportunities.

Using the camera aboard NASA's Earth Resources Research (ER-2) aircraft may be a feasible alternative. This option was proposed when NASA sought proposals for research using currently available NASA remote-

sensing data. However, NASA rejected this proposal because it was not responsive to the research announcement. Subsequently, no action to implement this option was taken by NASA.

Until the final disposition of the camera is decided, NASA has taken actions to protect it from environmental deterioration. Following its 1984 flight, the camera was placed in temporary storage at Johnson Space Center. In January 1988, the camera was transferred for long-term storage to Stennis Space Center, where a $60,000 facility was constructed to provide a secure, temperature- and humidity-controlled environment. The average operational cost for the building is approximately $7,700 per year.

Principal Findings

Large Format Camera Operated Successfully, but Using It Again on the Shuttle Would Not Be Cost-Effective

The Large Format Camera was flown aboard the space shuttle Challenger, mission STS 41-G, from October 5 to 13, 1984. It was considered completely successful in meeting its objectives, which were to (1) demonstrate that high-quality film imagery could be produced in space and (2) acquire high-resolution stereoscopic imagery to aid in the development of photographic interpretation and analysis techniques. Of the 2,247 frames of imagery, about 60 percent were cloud free. NASA intended to use the Large Format Camera a second time in November 1986. However, it canceled its plans after the Challenger accident in January 1986. NASA officials now cite the following reasons that using the camera on the shuttle is not commercially feasible: (1) the high costs associated with shuttle flights, (2) a lack of acceptable flight patterns for using the camera because of the planned angles of flight for future missions, (3) little or no available cargo space on shuttle flights in the near future, and (4) a lack of confidence in the size of the market for the camera's products.

In 1987, NASA estimated transportation costs for the camera at $20 million per flight. At that time, three private sector companies expressed interest in using the camera, but lost interest after being advised of the cost.

Using the Large Format Camera on the Space Station Is Not Considered a Realistic Option

The space station is currently scheduled to be launched in sections starting around 1995, but the program has been in a state of flux. In addition to the program's uncertainties, NASA officials do not believe that the space station is a realistic option for using the Large Format Camera because (1) the station's design restrictions and flight pattern limitations will limit picture-taking opportunities, (2) cargo space on the shuttle to transport the camera to the station might not be available, and (3) it could be difficult to retrieve the camera's film.

Using the Camera on the ER-2 Aircraft Is Viewed Favorably

In 1987, Itek Optical Systems (the builder and developer of the camera) and Autometric, Incorporated (which contracted with NASA to study the feasibility of commercializing the camera), in association with others, proposed using the camera aboard the ER-2 aircraft as an alternative flight option. (The ER-2 aircraft is based at NASA's Ames Research Center and operates at an altitude of about 60,000 feet.) Also, some government and private industry officials have expressed interest in this alternative.

Use of the ER-2 aircraft may be the most feasible use of the camera. Though the camera's capabilities would not be fully exercised at the much lower altitude flown by the ER-2 aircraft, according to private industry, some government officials, and other interested parties, it would provide more cost-effective area coverage than is possible through other similar camera systems currently available. Some NASA and private industry officials estimate that it will cost approximately $7500,000 to prepare and integrate the camera for use in the ER-2 aircraft. This estimate, however, does not include operating costs, which will vary, depending on flying time. To date, however, no action to implement this option has been taken by NASA. According to NASA, the cost-effectiveness of using the camera on the ER-2 aircraft versus using other aerial cameras has not been established. NASA pointed out that a number of factors would need to be considered in arriving at a cost-effectiveness assessment, including the area covered by the camera and the resolution of the pictures.

Commercialization Efforts Have Not Been Successful

Efforts thus far to market the camera's imagery have not been successful. In 1985, NASA reached an agreement with Martel Laboratories, Incorporated, to sell copies of the camera's flight imagery to U.S. private and commercial users. Under the agreement, which expired in November 1988, Martel paid NASA $100 for a copy of the imagery taken by the Large Format Camera during the October 1984 mission and agreed to spend $35,000 to promote and market it. Over the 3-year

period of its agreement, Martel reported commercial sales losses of over $60,000.

In 1985 and 1986, NASA awarded contracts for approximately $550,000 to Autometric, Incorporated, to explore applications and commercialization options for the camera. While these studies concluded that there was a potential commercial market for Large Format Camera products if they continued to be made available from further flights, the studies did not address the cost-effectiveness of flying the Large Format Camera on the shuttle or industry's potential to recover those costs from the sales of flight imagery.

In 1987, NASA held discussions with private companies on commercializing the camera. However, these companies lost interest after being advised of the $20 million per-flight cost to use the camera on the shuttle.

Recommendations

GAO recommends that the NASA Administrator take the following actions regarding the Large Format Camera. First, consider using the camera on an aircraft such as the ER-2. Second, if aircraft use is determined to be infeasible, consider transferring the camera to a museum, such as the National Air and Space Museum.

Agency Comments

In commenting on a draft of GAO's report, NASA generally agreed with GAO's findings and recommendations and plans to take actions to implement the recommendations. Specifically, NASA plans to solicit the private sector for expressions of interest on use of the Large Format Camera, at no cost to the government, in an aircraft such as the ER-2. NASA indicated that further action would be guided by the private sector response.

Contents

Executive Summary		2
Chapter 1 Introduction		8
	Mission Results and Current Status of the Camera	10
	Development, Procurement, and Other Costs	13
	Objectives, Scope, and Methodology	14
Chapter 2 Efforts to Commercialize the Large Format Camera and Its Products		15
	High Shuttle Transportation Costs Deter Private Investment	15
	Limited Interest in Purchasing Flight Film	16
	Studies Report on the Feasibility of Developing Commercial Markets	17
	Conclusions	17
Chapter 3 Options for Future Use of the Large Format Camera		19
	Continued Flights on the Shuttle Are Not Likely	19
	Use on the Space Station Is Considered Unrealistic	20
	Flight on the Earth Resources Research Aircraft Viewed Favorably	20
	Display Camera in a Museum	21
	Conclusions	21
	Recommendations	22
	Agency Comments	22
Appendixes		
	Appendix I: Significant Events in the History of the Large Format Camera	24
	Appendix II: Comments From the National Aeronautics and Space Administration	26
	Appendix III: Major Contributors to This Report	28
Figures		
	Figure 1.1: Large Format Camera in Shuttle Bay	9
	Figure 1.2: Photograph Taken of the Eastern Florida Coast and the Kennedy Space Center by the Large Format Camera	11
	Figure 1.3: Photograph Taken of Massachusetts, Connecticut, Rhode Island, New Hampshire, and Vermont by the Large Format Camera	12
	Figure 1.4: Storage Facility for the Large Format Camera	13

Abbreviations

ER-2	Earth Resources Research Aircraft
EROS	Earth Resources Observation Systems
GAO	General Accounting Office
LANDSAT	Land Remote Sensing Satellite System
LFC	Large Format Camera
NASA	National Aeronautics and Space Administration

Chapter 1

Introduction

The Large Format Camera (LFC) was developed by the National Aeronautics and Space Administration (NASA) to demonstrate the feasibility of taking high-resolution three-dimensional photographs from space.[1] NASA working groups and representatives of the National Academy of Sciences believed that such a capability would contribute to the enhancement of worldwide topographic mapping. In addition, the camera was expected to have utility in scientific disciplines like geology, oceanography, hydrology, and archeology.

This camera is the primary component of the shuttle's Orbiter Camera Payload System, which consists of the LFC and the Attitude Reference System.[2] This system is made up of two additional cameras dedicated to taking simultaneous photographs of star fields, thus allowing each LFC image to be precisely located. Figure 1.1 shows the LFC.

Major attributes of the LFC are its high resolution and its wide field of view. This combination allows objects sized about 12 meters and up to be identified and accurately positioned within a very large area from low-earth orbit. Photography from the LFC complements data produced by other types of remote sensors, such as Land Remote Sensing Satellite System (LANDSAT) satellites.[3] Although the LFC does not provide the repetitive coverage of a satellite, it does provide finely resolved images capable of being viewed in three dimensions. This feature is not available from LANDSAT. Additionally, unlike the data collected by LANDSAT, the LFC's images do not require sophisticated computer processing for production.

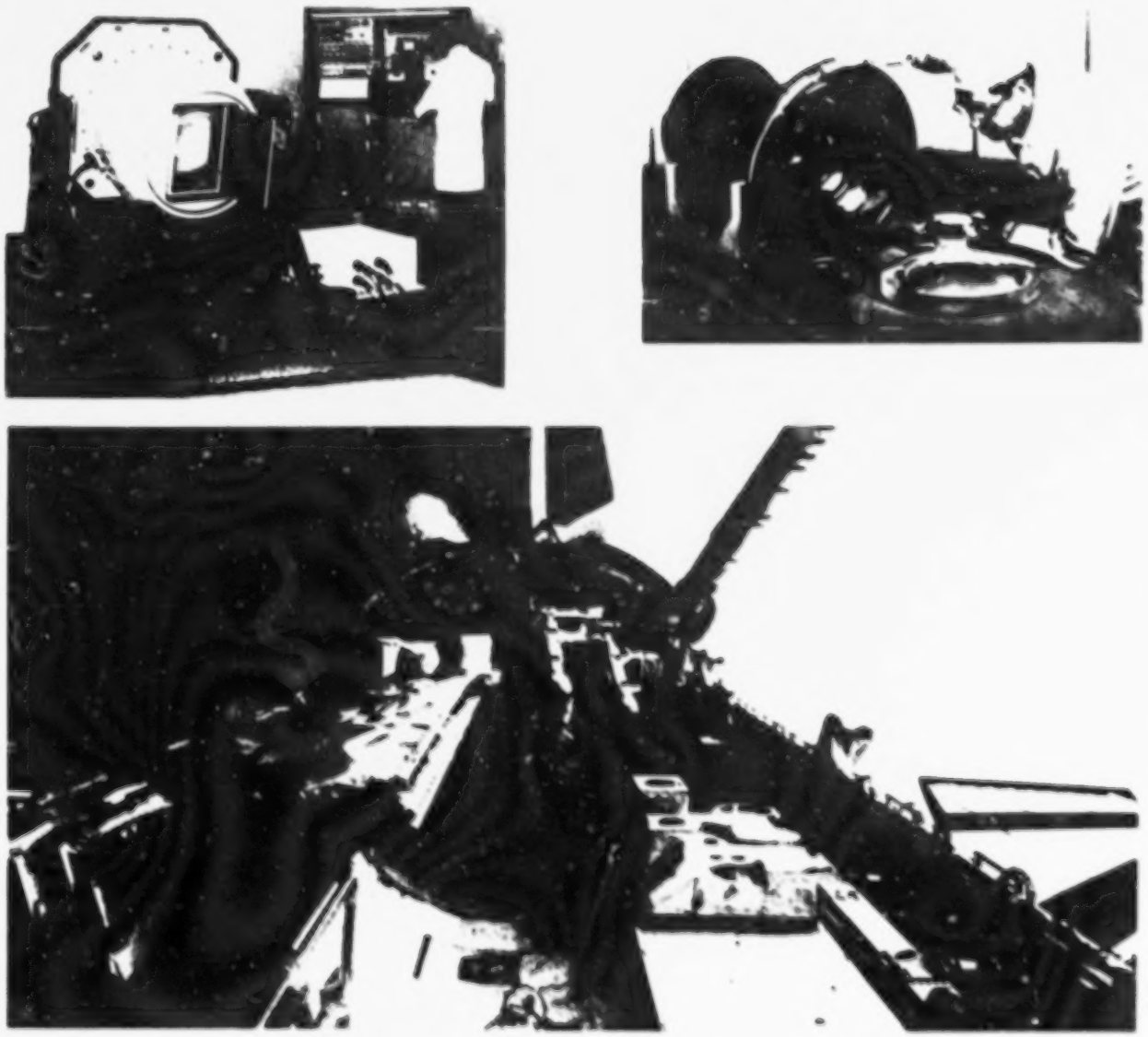
The concept for a space-based mapping camera dates back to the mid-1960s. However, actual development did not begin until 1976, when the Johnson Space Center submitted a proposal to NASA headquarters to acquire such a camera system for the shuttle. In November 1977, NASA awarded a contract to Itek Optical Systems to study the feasibility of developing a high-resolution camera. The camera ultimately developed

[1] The three-dimensional effect is seen only when the pictures are viewed through a stereoscope, an instrument with two eyepieces through which a pair of photographs of the same scene or subject, taken at slightly different angles, are viewed side by side. The two photographs are seen as a single picture appearing to have depth, or three dimensions.

[2] In aeronautics, "attitude" refers to the position of an aircraft or spacecraft in relation to a set reference point such as the horizon or a particular star.

[3] LANDSAT is a U.S. civilian land remote-sensing satellite system. The first LANDSAT was launched by NASA in 1972. Since then, four more have been built and launched. These satellites provide repetitive coverage of the earth's surface and transmit data back to earth ground stations, which process it on computer-compatible tapes or convert it by computer into photographic images.

Figure 1.1: Large Format Camera in Shuttle Bay



Note: The photograph on the top left shows the camera on a test stand, and the photograph on the top right shows the optical elements comprising the lens. In the bottom photograph, the camera is located to the immediate left of the two astronauts.

Source: Itek Optical Systems

to demonstrate this capability was the LFC, which weighed about 900 pounds and produced pictures measuring 9 by 18 inches. Each picture covered an area of 110 by 220 nautical miles from a typical shuttle altitude of 147 nautical miles. The camera uses black and white, color, and color infrared film on a roll measuring 9-1/2 inches wide by 4,000 feet long.

Mission Results and Current Status of the Camera

NASA's original plan for the camera was to demonstrate the worthiness of high-resolution space photography. Mission objectives were to (1) show that high-quality pictures could be produced in space and (2) acquire high-resolution three-dimensional pictures to aid in the development of photographic interpretation and analysis techniques. These objectives were successfully accomplished on shuttle flight STS 41-G, which flew from October 5 to 13, 1984. On this flight, the LFC shot 2,247 frames of film of which about 60 percent were cloud free. An additional 26 percent were considered marginally acceptable due to cloud cover, and 14 percent were unacceptable. Figures 1.2 and 1.3 show examples of the images the LFC produced.

Another flight to obtain pictures for analysis was scheduled for November 1986, but it was canceled because of the shuttle Challenger accident on January 28, 1986. After the accident, the camera was placed in temporary storage at Johnson Space Center, Houston, Texas. NASA officials never intended to use the camera on every shuttle mission. Rather, they expected that following the camera's successful demonstration, other government agencies or private companies with special interests in photographic applications would absorb the costs for further LFC flight.

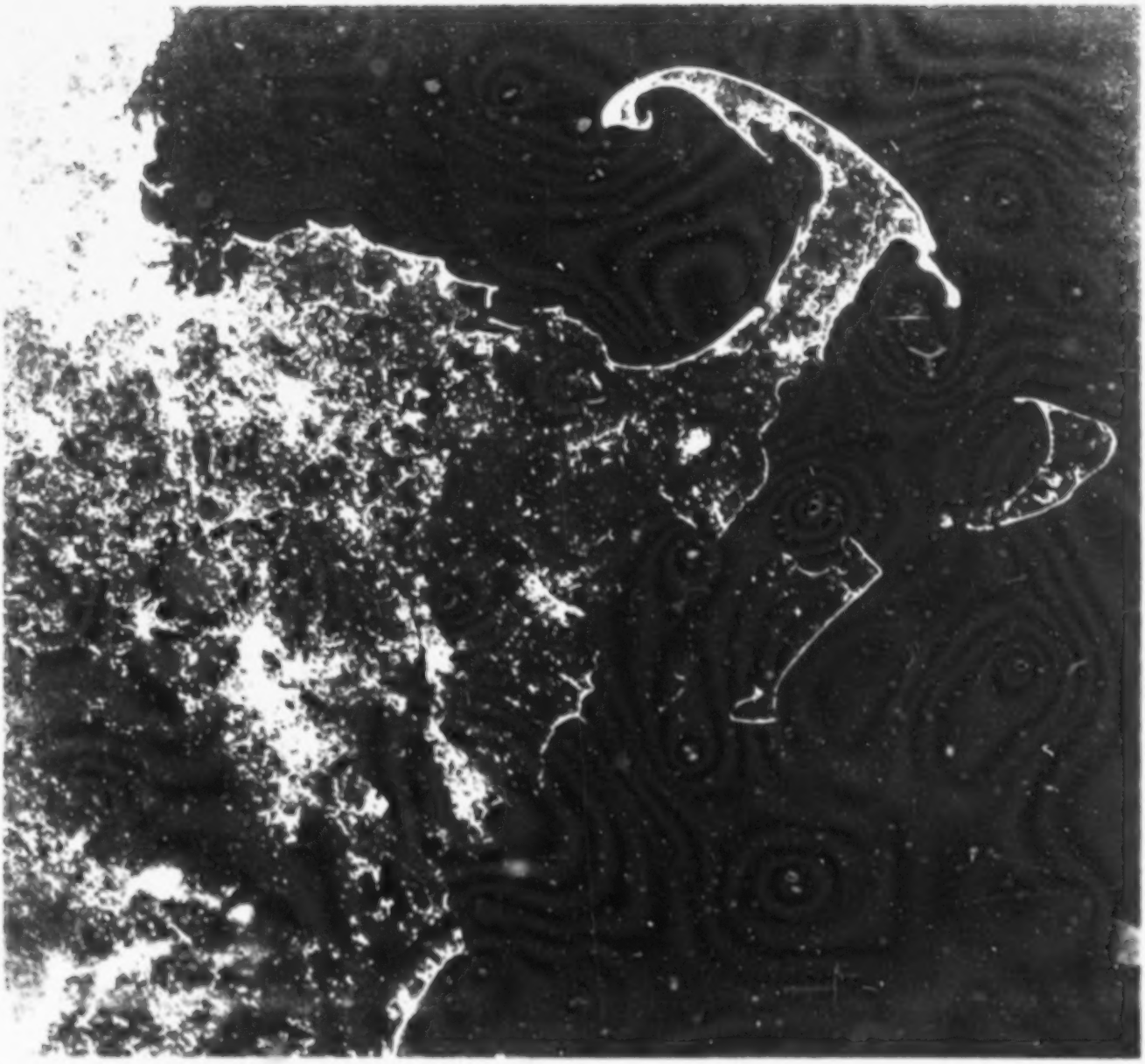
In April 1987, NASA headquarters decided to transfer the camera for long-term storage to the Stennis Space Center in Mississippi. At that time, NASA headquarters officials tasked Stennis officials to take the appropriate steps to further protect the camera by constructing a proper storage facility. Stennis officials contracted to have an environmentally controlled facility—building 8202—constructed at a cost of about $60,000.

Building 8202 is a windowless, cinder block building of 606 square feet of usable space, resembling a large garage. It has a removable front wall and contains its own heating and air-conditioning systems. A monitoring system continually checks the inside temperature and humidity levels and, if it senses unacceptable variances, sets off warning alarms. The

Figure 1.2: Photograph Taken of the Eastern Florida Coast and the Kennedy Space Center by the Large Format Camera

Note: Actual products from the LFC were pairs of overlapping images that had to be viewed through a stereoscope to realize the three dimensional effect.

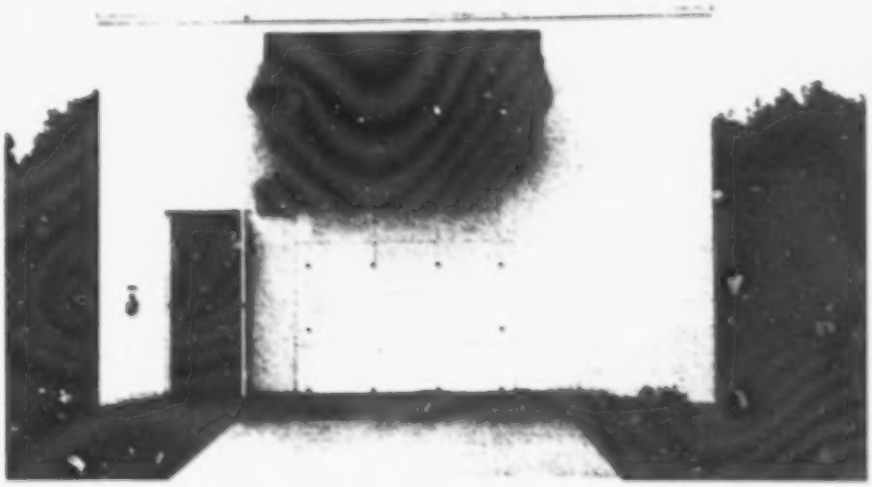
Source: NASA's Office of Space Science and Applications



average operational cost for upkeep of the building is approximately $7,700 per year.

The camera and its auxiliary pieces were hermetically sealed at Johnson Space Center before being shipped to Stennis in January 1988. Stennis officials believe, but cannot verify, that the LFC is in excellent condition because the boxes have remained sealed since their arrival. According to Stennis officials responsible for the safekeeping of the camera, it would cost about $500,000 to open the boxes for inspection, reassembly, and testing. When we visited the facility in December 1989, we found the building to be a suitable structure to house the camera boxes. Figure 1.4 shows a picture of this facility.

Figure 1.4: Storage Facility for the Large Format Camera



Source: Stennis Space Center

Development, Procurement, and Other Costs

The total cost to develop and procure the LFC was $11.4 million. This consisted of four contracts, including government-furnished equipment and totaling $9.5 million, which were awarded to Itek Optical Systems between November 1977 and April 1982. The remaining $1.9 million was spent for engineering and integration support, camera calibration, flight film, and film processing.

Subsequent attempts by NASA to commercialize the camera resulted in the award of one contract to Autometric, Incorporated, in January 1985

and another in September 1986. A total of $550,000 was spent to study (1) various applications of the LFC and (2) the feasibility of commercializing the camera. Also, in January 1989, Lockheed Engineering and Sciences Company was tasked to explore various options for further LFC flights. This effort, which was part of Stennis Space Center's mission support contract, cost about $12,000. A summary of significant events in the history of the LFC is presented in appendix I.

Objectives, Scope, and Methodology

The Chairman of the Senate Committee on Governmental Affairs requested that we determine why the camera has been in storage since its first and only flight in 1984 and whether the LFC could be used in the future. To address these issues, we reviewed documents and interviewed NASA and contractor officials associated with developing, flying, and marketing the LFC and its products. We performed our work at NASA Headquarters, Washington, D.C., and at the Stennis Space Center, Mississippi.

Our work was conducted from November 1989 to April 1990 in accordance with generally accepted government auditing standards. NASA provided comments on a draft of this report (see app. II).

Efforts to Commercialize the Large Format Camera and Its Products

Between 1985 and 1988, NASA attempted to commercialize the LFC and its film products taken during the 1984 flight. We found that these attempts were unsuccessful because (1) no private entity was willing to pay the high costs associated with using the camera on the shuttle, (2) the primary users of LFC data were scientific researchers who were able to purchase the flight film from the U.S. Geological Survey at reduced prices, and (3) the one-time use of the LFC did not provide sufficient data to support a commercial market.

High Shuttle Transportation Costs Deter Private Investment

In early 1986, Itek Optical Systems, the developer and builder of the LFC, contacted NASA regarding the possibility of using the LFC on the shuttle on a commercial basis.[1] While discussions with Itek proceeded, NASA issued an announcement in the Commerce Business Daily on October 2, 1986, seeking expressions of interest from private companies to commercially operate the LFC. Three companies, including Itek, responded to the announcement, but only Itek began serious discussions. These discussions, however, ended in early 1987 after NASA estimated that it would cost about $20 million to use the LFC on the shuttle. Itek officials stated that they had lost interest in using the camera after determining that with such high costs, they could not expect a sufficient return on their investment to make the venture commercially feasible.

Since 1987, no other private entity has expressed interest in commercially using the LFC on the shuttle. NASA officials cite the following reasons that using the LFC on the shuttle is not commercially feasible: (1) the high costs associated with shuttle flights, (2) a lack of acceptable flight patterns for using the camera because of the planned angles of flight for future missions, (3) little or no available cargo space on shuttle flights in the near future, and (4) a lack of confidence in the size of the market for the LFC's products. NASA's interest in using the LFC again is also limited because, after proving its technological capabilities, the camera is not needed to meet any additional scientific or engineering research and development objectives.

[1]Earlier, in March 1986, Itek had applied for and received a license from the Department of Commerce to operate the LFC on the space shuttle, under the terms of section 401 of the Commercial Land Remote-Sensing Commercialization Act of 1984. Such a license was necessary to operate a remote-sensing system aboard a U.S. spacecraft or launch vehicle. It did not guarantee Itek access to the camera or flight opportunity; it merely authorized Itek to use it, pending negotiation with NASA.

Limited Interest in Purchasing Flight Film

In November 1985, NASA reached an agreement with Martel Laboratories, Incorporated, to sell copies of LFC products to private and commercial users, pursuant to section 503 of the Land Remote-Sensing Commercialization Act of 1984 (P.L. 98-365). This act stipulates that data gathered from U.S. space programs may be sold commercially on a nondiscriminatory basis to interested commercial and private users. Under the terms of the agreement, which expired in November 1988, Martel paid NASA $100 for a set of the LFC flight film and agreed to invest $35,000 to promote sales of the photographs and to help develop a market for the products.

In addition to the photographs available through Martel Laboratories, copies of individual photographs were also made available to federally funded and other certified researchers[2] (including foreign scientists conducting cooperative research with U.S. scientists) by the U.S. Geological Survey through its Earth Resources Observation System (EROS) Data Center, in Sioux Falls, South Dakota. This arrangement is pursuant to section 502 of P.L. 98-365, which stipulates that all remote-sensing data gathered from U.S. space programs may be made available to federally funded researchers.

Martel reported losses of over $60,000 during its 3-year agreement with NASA.[1] A review of the company's reports revealed its disappointment over its flight film commercialization venture. In fact, in terms of the number of frames of film sold, EROS Data Center sales were about eight times Martel Laboratories' sales. NASA officials stated that, in their opinion, Martel Laboratories had made only a cursory effort to market the LFC flight film. Martel officials believed that their market had been undermined by the availability of the same data to researchers from EROS Data Center at a lower cost.

Martel also believed that EROS's process for verifying "research purposes" was weak and could be easily circumvented. Despite these arguments, however, Martel was aware of the research certification process before it competed for the distribution rights. In fact, according to a Martel official, Martel's bid of $100 for the film distribution rights was probably based, in part, on its belief that the commercial market for LFC products had been effectively destroyed by EROS's distribution of LFC

[2]The U.S. Geological Survey required researchers to complete affidavits stating that the purchased LFC photographs would be used for "bona fide" research purposes.

[1]Martel continues to sell LFC photographs to interested commercial parties but no longer reports sales figures to NASA.

film products. It appears likely, however, that if additional flights of the LFC had taken place, Martel's previous experience marketing the imagery would have given it an upper hand in future film commercialization.

Studies Report on the Feasibility of Developing Commercial Markets

After the successful use of the LFC in space, NASA awarded two contracts to study the commercial applications of LFC imagery. In January 1985 and September 1986, Autometric, Incorporated, a professional services company that specializes in the analysis of land remote-sensing data and photographic interpretation, was awarded these contracts to study the feasibility of using LFC products for different scientific and commercial applications and to analyze potential markets for LFC data.

After completing the first contract in August 1985, Autometric concluded that there were commercial uses for the LFC data but that additional work was needed to optimize data collection, handling, and processing. After completing the second contract, in September 1988, Autometric concluded that there could be a viable commercial market if certain conditions were met. First, more data needed to be collected from additional shuttle flights of the LFC, and second, a larger customer base needed to be developed to fully exploit perceived commercial markets.[4] Autometric also concluded that the capabilities of the LFC were sufficiently distinct from those of LANDSAT or other remote-sensing satellite systems to ensure that the LFC's unique data was both necessary and complementary.

Conclusions

In response to the 1987 estimate of $20 million to use the LFC on the shuttle again, private entities lost interest in financing such a venture. Although Autometric reported that a potential commercial market did exist for LFC data products, its studies appear to be overly optimistic since they do not address the most critical concerns regarding the LFC's commercialization: the cost-effectiveness of using the LFC on the shuttle and the potential to recover such costs from the private sales of the flight film and related products. Additionally, the experience of Martel Laboratories indicates that the majority of interest in LFC flight film has been expressed by scientific researchers, who are able to obtain similar data at reduced prices from the EROS Data Center. Finally, because of the lack of available cargo space on the shuttle and the limited number of flights scheduled with the angle favorable for using the camera, the

[4]The U.S. government was identified in the study as the single largest user of LFC data.

future use of the LFC on a commercial basis appears most unlikely unless some other platform such as an aircraft can be used.

Options for Future Use of the Large Format Camera

In our opinion, Stennis officials took appropriate actions in constructing a facility to protect the camera when it was decided that the camera be placed in long-term storage. However, some more practical disposition of the camera now seems warranted since some government agencies and private industry officials have expressed interest in seeing the LFC used again.

Industry's primary interest is in the potential financial rewards of using the camera, while some government agencies and other interested parties focus on the potential benefits of using the camera for environmental monitoring. Despite the interest expressed, however, no agency or company seems willing to pay the high costs of using the camera again on the shuttle.

In lieu of using the LFC on the shuttle, private industry took the lead in seeking alternative flight options for using the camera. Specifically, in 1987, a group of companies proposed that the camera be used on NASA's Earth Resources Research (ER-2) aircraft, which is based at NASA's Ames Research Center and flown at an altitude of approximately 60,000 feet. To date, NASA has not formally taken any action to exercise this option. However, in January 1989, in an effort to look at alternative flight options, the Stennis Space Center tasked its mission support contractor, Lockheed Engineering and Sciences Company, to study potential LFC uses. Lockheed's draft study reviewed the potential for using the camera aboard the shuttle, the space station, and the ER-2 aircraft. The draft study did not assess the benefits of one flight option over another, but it described the ER-2 aircraft as an attractive option, and we believe that it is the most likely option for using the LFC.

Continued Flights on the Shuttle Are Not Likely

While private companies have expressed interest in using the LFC again on the shuttle, the $20 million per-flight cost estimate does not make it a reasonable business venture. As discussed in chapter 2, other factors, such as cargo space limitations, the planned angles of flight, and the problems associated with marketing LFC products, do not make future shuttle flight for the camera a likely possibility. No formal discussions have taken place between NASA and private industry on using the camera on the shuttle since early 1987. As of March 1990, NASA officials believed that using the camera on the shuttle again was unlikely.

Use on the Space Station Is Considered Unrealistic

NASA's space station, which is scheduled to be launched in sections starting in the mid-1990s, will serve as a research laboratory in space. Though Lockheed addressed the feasibility of using the LFC on the station and found that it could be attached to part of the station's span, NASA officials do not believe that the station is a realistic option for using the camera.

NASA officials cited the following reasons that using the LFC on the station would be unrealistic: (1) they are uncertain of when the station will be operational, (2) the station's design restrictions and flight pattern will limit the LFC's picture-taking opportunities, (3) it could be difficult to retrieve LFC film, and (4) cargo space on the shuttle to transport the camera to the station will be limited. In addition, they do not think that private industry is interested in this option.

Flight on the Earth Resources Research Aircraft Viewed Favorably

Using the LFC on the ER-2 aircraft was formally proposed to NASA in 1987. In responding to a NASA Research Announcement, Itek Optical Systems and Autometric, Incorporated (in association with others, including NASA's Ames Research Center), proposed using the camera on the aircraft and marketing the imagery. The research announcement, however, was specifically seeking proposals for research using currently available NASA remote-sensing data. Proposing additional use of the camera on an ER-2 aircraft was deemed by the NASA reviewing panel as not responsive to the announcement. Thus, the proposal was rejected, and its possible merits were never formally analyzed or reviewed. Since this proposal, private industry has not formally taken additional action to pursue using the camera on this aircraft.

Although the LFC's optimal performance is gained from operating it from low-earth orbit, NASA officials stated that the LFC had been designed with future aircraft use in mind. Other NASA officials, however, stated that they could not understand why anyone would want to use the camera on an aircraft. Using the camera on an ER-2 aircraft, which usually flies at an altitude of approximately 60,000 feet, would require some modifications to the camera and to the aircraft. For example, (1) the Attitude Reference System would not be needed because it uses its star-fixing capability to pinpoint the LFC's position in low-earth orbit and would be unnecessary at 60,000 feet, and (2) brackets would have to be constructed and placed in the aircraft to hold the camera.

On the other hand, private industry, some government officials, and other interested parties told us that, in spite of problems associated with

marketing LFC products and the fact that the camera would not be operated at its optimum efficiency, using the camera on the ER-2 aircraft could be very beneficial. For example, the camera could provide environmental monitoring information—on crop damage, acid rain, snow melting, and natural disasters—at lower costs, with a wider field of view and better resolution than are currently possible with other aerial cameras. In commenting on this report, NASA officials pointed out that the major advantage of the LFC is its high resolution, not necessarily its area of coverage. They stated that many other factors needed to be considered in a cost-effectiveness assessment to determine the LFC's value for use on the ER-2.

As of February 1990, private industry was still expressing interest in using the camera on the ER-2 aircraft, but the cost of operating such a venture was of major concern. NASA and private industry officials estimate that it will cost approximately $500,000 to prepare and integrate the camera for use in the ER-2 aircraft. This estimate, however, does not include operating costs, which will vary, depending on flying time. Itek officials pointed out that the successful commercialization of the LFC on the ER-2 aircraft would depend on the company's (1) obtaining complete data and distribution rights and (2) securing the ability to fly missions outside of the United States.

Display Camera in a Museum

A mock-up of the LFC is currently on display at the National Air and Space Museum's "Looking at Earth" gallery. According to the gallery's curator, if NASA determined that it had no further use for the LFC, the museum would be interested in adding it to the permanent collection in place of the mock-up.

Conclusions

Given the lack of opportunity and the high cost to use the camera on the shuttle and the uncertain development schedule of the space station program, the most probable alternative for using the LFC is aboard the ER-2 aircraft. If NASA and private industry determine that the camera cannot be successfully used on the ER-2 aircraft and that no other viable commercial opportunities exist, indefinitely maintaining the camera in storage at the Stennis Space Center does not appear to be reasonable. Displaying the camera in a museum might be a more reasonable disposition for the LFC.

Recommendations

We recommend that the NASA Administrator take the following actions regarding the LFC. First, consider using the camera on an aircraft, such as the ER-2. Second, if aircraft use is determined to be infeasible, consider transferring the camera to a museum, such as the National Air and Space Museum.

Agency Comments

In commenting on a draft of this report, NASA generally agreed with our findings and recommendations and plans to take actions to implement the recommendations (see app. II). Specifically, NASA plans to solicit the private sector for expressions of interest on use of the Large Format Camera, at no cost to the government, in an aircraft such as the ER-2. NASA indicated that further action would be guided by the private sector's response.

NASA officials also provided some editorial suggestions and technical clarifications, which we have incorporated where appropriate throughout the report.

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Significant Events in the History of the Large Format Camera

1965	A NASA Working Group recommended the development of a Large Format Camera (LFC).
November 1976	Johnson Space Center proposed the development of the Orbiter Camera including an LFC and an Attitude Reference System.
November 1977	A contract for an LFC feasibility study was awarded to Itek Optical Systems.
July 1978	A contract to develop LFC hardware was awarded to Itek Optical Systems.
July 1984	Plans to fly the LFC on shuttle mission 41-D were canceled because the mission was aborted.
October 1984	The LFC was successfully flown on shuttle mission 41-G.
January 1985	A contract to study LFC applications was awarded to Autometric, Incorporated.
Early 1985	The LFC was put in temporary storage at Johnson Space Center.
June 1985	NASA issued a notice inviting offers for commercializing the imagery taken by the LFC on its October 1984 flight.
November 1985	An agreement was reached with Martel Laboratories, Incorporated, to market the LFC imagery.
March 1986	A license was awarded by the Department of Commerce to Itek Optical Systems to operate the LFC as a commercial venture and to market data from the LFC.

September 1986	A contract to study LFC commercialization was awarded to Autometric, Incorporated.
October 1986	NASA issued a notice in the Commerce Business Daily seeking expressions of interest from the private sector for commercial use of the LFC on the shuttle.
February 1987	NASA estimated costs for flying the LFC on the shuttle to be approximately $20 million,and prospective companies lost interest in the camera as a commercial venture.
March 1987	Martel Laboratories, Incorporated, reported losses of approximately $66,000 on LFC imagery sales for March through December 1986. (The reported loss is due primarily to business start-up costs.)
January 1988	The boxes containing the LFC were shipped from Johnson Space Center to Stennis Space Center and stored in building 8202.
May 1988	Martel Laboratories, Incorporated, reported LFC imagery net sales of approximately $2,400 for January through December 1987.
January 1989	The Lockheed Engineering and Sciences Company, Stennis Space Center's mission support contractor, was tasked to study the possible flight options for using the LFC.
May 1989	Martel Laboratories, Incorporated, reported LFC imagery net sales of approximately $2,000 for January through December 1988.
October 1989	The Lockheed Engineering and Sciences Company issued its preliminary LFC flight options study.

Comments From the National Aeronautics and Space Administration

Note: GAO's comment supplementing those in the report text appears at the end of this appendix.

National Aeronautics and
Space Administration

Washington, D.C.
20546

Office of the Administrator

MAY 8 1990

Mr. Frank C. Conahan
Assistant Comptroller General
National Security and International
Affairs Division
General Accounting Office
Washington, DC 20548

Dear Mr. Conahan:

See comment 1.

The National Aeronautics and Space Administration (NASA) appreciates the opportunity to review and comment on the enclosed General Accounting Office (GAO) draft report entitled, Technology Development: Future Use of NASA's Large Format Camera Is Uncertain (GAO Assignment code 397010).

In general, NASA is in accord with the principal findings and recommendations of the report. We plan to take action to implement these recommendations. Initially, NASA is planning to solicit expressions of interest from the private sector for use of the camera in an aircraft at no cost to the government. This solicitation would be released in the Commerce Business Daily. Further action will be guided by responses to this request.

It should be noted that the cost effectiveness of using the Large Format Camera (LFC) on an aircraft versus using other aerial cameras has not been established. The major advantage of the LFC is its high resolution. It is important to note that the area covered by the six inch aerial camera from 60,000 feet is actually larger, albeit with lower resolution, than that from the LFC. Many other factors need to be considered in arriving at a cost effectiveness assessment. Additional comments for clarification and technical accuracy were provided to your staff at a meeting on April 26, 1990, and properly dispositioned during a telecon on April 27, 1990.

Sincerely,

John E. O'Brien
Assistant Deputy Administrator

Enclosure

The following is GAO's comment on NASA's letter dated May 8, 1990.

GAO Comment

1. We have modified the report where appropriate to incorporate the clarifications provided by NASA officials.

Major Contributors to This Report

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